TD-LTE Industry and Market Development

Global TD-LTE Initiative

2013-2-20

1. TD-LTE Industry Development

a) Industry Overview

Till now, TD-LTE has built up a global industry ecosystem with broad support from the global wireless industry, including infrastructure equipments, chipsets, terminals, testing and certification instruments. The end-to-end TD-LTE products are commercial available and already been proved with large-scale commercial network deployment.

Table 1 Global TD-LTE Industry Ecosystem Composition

Products	Supporting Enterprises
System equipment	Alcatel-Lucent, Datang Mobile, Ericsson, Fiberhome, Huawei, NSN, POSTCOM, Potevio and Samsung, ZTE,
Chipsets	MediaTek, Sony Ericsson, CYIT, Hisilicon, Innofidei, Marvell, Qualcomm, Sequans, Spreadtrum, STE, Leadcore National technology, Broadcom, Altair, VIA, Wavesat, Renesas, Runcom, etc.
Terminals	Huawei, Coolpad, Samsung, Nokia, Quanta, Acer, ZTE, etc.
Test instruments	Datang Mobile, StarPoint, Transcom, CETC41, Gulfstream, Rohde & Schwarz, Agilent, Anritsu, Aeroflex, Anite, etc.

Source: GTI

As mentioned in the above table, the world's leading telecommunications manufacturers are fully committed to TD-LTE product development. All top 5 system equipment vendors have participated in the TD-LTE industry ecosystem development as well as the leading chipset vendors, such as Qualcomm, STE and MTK. The completeness and strength of the industry ecosystem has laid a solid foundation for

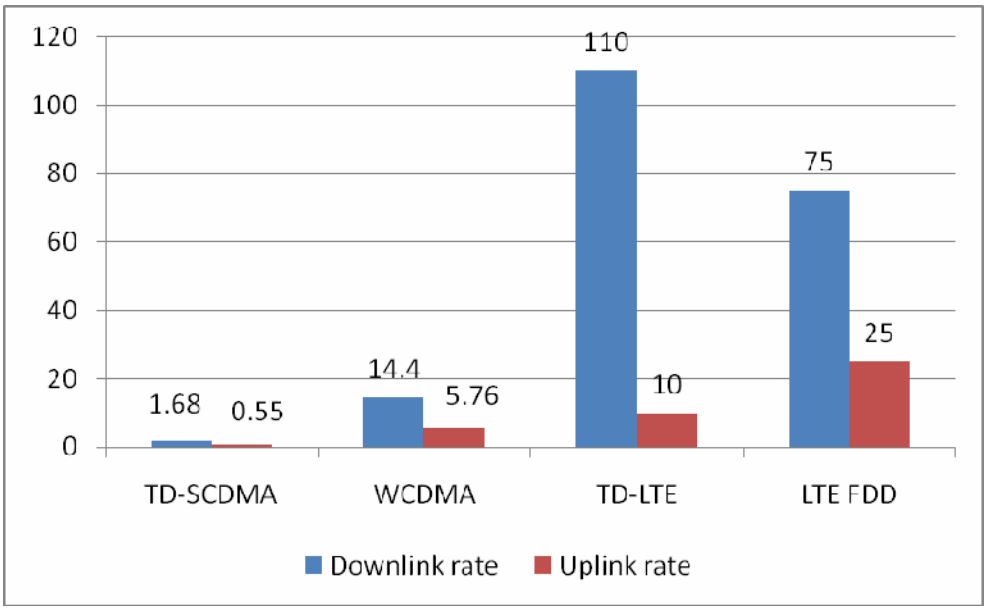
the rapid development of TD-LTE commercialization.

b) System Equipment

TD-LTE system equipments are rapidly maturing and becoming fully commercially available. The TD-LTE system was first commercial released in 2010. The 2.3GHz TD-LTE products was released in 2010 Q2 and 2.6GHz products in 2010 Q3. Till now, there are 10 major vendors providing products complied to 3GPP Release 8 (R8) standard, and 6 vendors are able to provide R9 standard commercial products. 3.5GHz products are also commercial available since 2012.

TD-LTE system equipments are commercial available with proven performance in large-scale commercial and trial networks in many countries globally.

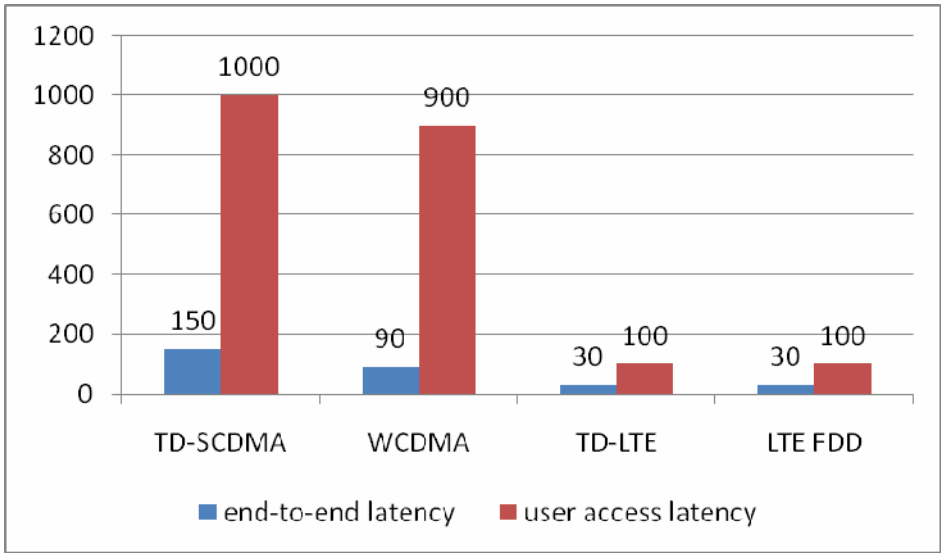
Figure 1 TD-LTE Peak Rate Statistics (Unit: Mbps)



Source: test measured data in China Mobile large-scale trial network

The DL/UL ratio in above figure is 4:2 for TD-SCDMA and 3:1 for TD-LTE. The DL/UL rate will be varied with different ratios.

Figure 2 TD-LTE User Plane Latency (mm)



Source: test measured data in China Mobile large-scale trial network

According to the test results, TD-LTE and LTE FDD have mostly equal performance on latency.

With the same frequency, the coverage performance of TD-LTE and LTE FDD are roughly equal, and TD-LTE downlink coverage is superior to LTE FDD. The uplink coverage is related to the downlink/uplink ratio; TD-LTE uplink coverage is less than LTE FDD with the downlink/uplink ratio 3:1 and has similar coverage performance with the downlink/uplink ratio 2:2 using 8 antennas.

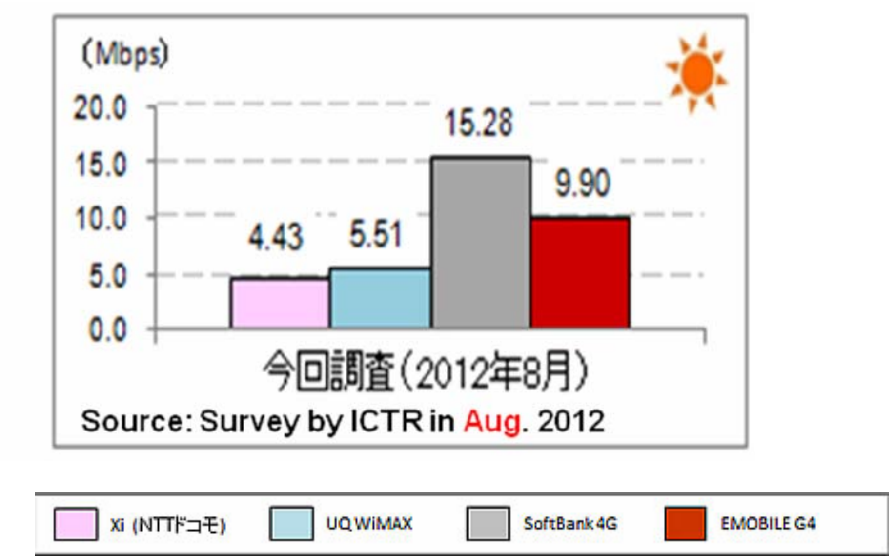
With respect to the concurrent data service user capacity, TD-LTE and LTE FDD have the same theoretical capacity (TD-LTE measured data: 200 users / cell).

Softbank network is currently the most complex commercial TD-LTE network in the world. With its commercial network deployment, TD-LTE has been sufficiently validated within all network scenarios for commercial launch.

In Tokyo, Japan, with all of the urban congestion and complex networking environment, TD-LTE vendors have developed a micro-cellular solutions, with station spacing of 100-200 meters, effectively solving the coverage problems in a dense urban space complex environment. Additionally, in order to solve the intra-frequency network interference, a variety of advanced technologies, including multi-antenna

Beamforming, SFN (Single Frequency Network), adaptive ICIC and SON are adopted. Especially, using SFN technology in edge area and SDMA (Space-Division Multiple Access) in non-edge area can significantly reduce interference and enhance the network edge rate. In the third party (ICT) performance assessment for Japan's four 4G networks, Softbank's TD-LTE network performance is recognized as being optimal.

Figure 3 ICT's Assessment Results for the Four 4G Networks in Japan



Source: ICT Report

The excellent performance of the TD-LTE network protects the rapid growth of Softbank TD-LTE users. Since the network commercially launched in late February 2012, number of subscriber has been quickly raised to over 520,000, which brings Softbank high confidence to develop their TD-LTE network. The Softbank TD-LTE commercial network has become a global TD-LTE network construction model, which can provide valuable experience for TD-LTE network deployment globally.

c) Chipsets

Both of TD-LTE single-mode and multi-mode chipsets have reached commercial availability. Until the end of 2012, more than 17 chipset companies around the world have invested or committed to the research and development of

TD-LTE chipsets. Two of them have launched 5-mode TD-LTE chipsets, while other two companies launched 4-mode chipsets and three companies launched 3-mode chipsets. The 40-nanometer technology has been applied to TD-LTE chipset with high maturity, which can fully meet the business demand for diverse devices such as Customer Premise Equipments (CPE) and portable MiFi devices. Furthermore, the 28-nanometer technology will be widely adapted in all TD-LTE chipset manufacturers within 2013. It will significantly improve the chipset performance, such as power consumption and integration capability.

Table 2 Part of the TD-LTE Multimode Chipset

Manufacturer	**Type**	**Multi-mode and multi-band support capabilities**
Qualcomm	MSM8960	6-mode supported : GSM/CDMA2000/WCDMA/TD-SCDMA/LTE FDD/TD-LTE
Hisilicon	Balong710	5-mode supported: GSM/WCDMA /TD-SCDMA/LTE FDD/TD-LTE
Innofidei	WD5000	5-mode supported: GSM/WCDMA /TD-SCDMA/LTE FDD/TD-LTE
Leadcore	LC1761	5-mode supported: GSM/WCDMA /TD-SCDMA/LTE FDD/TD-LTE
Spreadtrum	SC9610 SC9620	➢ SC9610 supports 3-mode: TD-SCDMA/GGE/ TD-LTE ➢ SC9620 supports 5-mode: GSM/WCDMA/TD-SCDMA/LTE

		FDD/TD-LTE
STE	M7400	5-mode supported: GSM/WCDMA /TD-SCDMA/LTE FDD/TD-LTE
Intel	MM7060	3-mode supported now: GSM/WCDMA /LTE FDD (5-mode including TD-LTE will be supported in 2013)
Altair	FG3100	2-mode supported: TD-LTE/LTE FDD

Source: provided by chipset companies and summarized by GTI

d) Terminals

TD-LTE data terminals are commercially available with diverse selection. The TD-LTE smart phones have been commercially launched to the market since 2H of 2012. According to the GSA (Global mobile Supplier Alliance) statistics, the total number of TD-LTE terminals has reached 125 by Feb 3, 2013. The type and frequency distribution are shown in the below tables.

Table 3 TD-LTE Terminal Type Distribution

Module	17
Phone	14
Router	61
Tablet	2
USB modem	31

Source: GSA

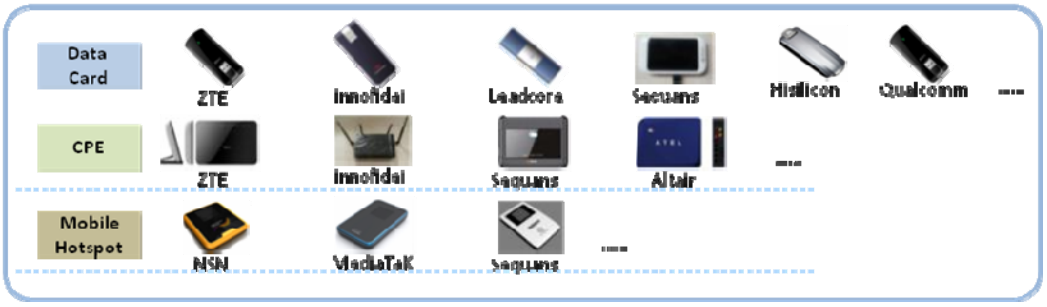
Table 4 TD-LTE Terminal Frequency Distribution

TDD 2300(Band 40)	82
TDD 2600(Band 38)	88
TDD 2600 US(Band 41)	20
TDD 1900	4
TDD 3500(Band 42/43)	7

Source: GSA

A variety of data cards, MiFi devices and CPE have been widely used in a dozen global commercial networks serving more than 1 million users. These data terminals provide a comprehensive selection of high-speed mobile broadband services for all types of consumers. The following figure shows various types of data terminals.

Figure 4 Mainstream Device Vendors Joined TDD Ecosystem and TDD Data Terminals Are Diverse



In September 2012, Japan's Softbank launched the world's first TD-LTE supported multimode smart phones at 2.5 GHz commercially. Saudi STC and India Bharti also announced the availability of multimode smartphone.

Table 5 TD-LTE Commercial Smartphones Released by Softbank

Type	STREAM 201HW (Ascend P1 LTE)	RAZR M 201M	AQUOS PHONE Xx 203SH	ARROWS A 201F	PANTONE 6 200SH	HONEY BEE 201K
Picture						
Vendor	HUAWEI	MOTOROLA	SHARP	FUJITSU 富士通	SHARP	KYOCERA
Time	2012.10	2012.10	2013.03	2013.02	2012.12	2013.01
Chipset	MSM8960 Dual-core 1.5G	MSM8960 Dual-core 1.5G	APQ8064 Quad-core 1.5G	APQ8064 Quad-core 1.5G	MSM8960 Dual-core 1.5G	MSM8960 Dual-core 1.5G
Frequency	LTE AXGP (2.6G)/UMTS 900/1500/2100MHz/GSM 900/1800/1900MHz					
Screen	4.3 inch, qHD	4.3 inch, qHD	4.9 inch, 720P	4.7 inch, 720P	4.5 inch, 720P	3.7 inch, 800×480
Camera	8M/1.3M	8M/0.3M	16.3M/1.2M	13.1M/1.2M	13.1M/0.3M	8M/2M
ROM	4G	8G	32G	32G	4G	4G
RAM	1G	1G	2G	2G	1G	1G
Highlight	Fast boot Fast camera	KEVLAR back water-repellent Nanocoating	High-end hardware 2200mAh battery Water-proof	High-end hardware 2420mAh battery Fast charging Water-proof	25 colors 7 color covers	Water-proof

In addition, Samsung's TD-LTE phone is under testing and will be available in 2013. The iPhone is expected to support TD-LTE in 2013. With more smart-phones commercially launched, TD-LTE ecosystem is getting more maturing and the number of TD-LTE subscribers is estimated to grow fast.

e) Test Instruments

TD-LTE test instruments will keep the same pace as LTE FDD, and strongly support the TD-LTE development and commercialization. Initiated from the beginning, TD-LTE has been widely supported by the major test instrument providers based on the common-platform with LTE FDD.

Table 6 TD-LTE Test Instrument Market Situation

Product areas	Number of vendors
Terminal Radio Communication Tester	7
Protocol Conformance Test Instrument	6
Sweep Generator	7
Vector Signal Generator	3

Air Interface Monitoring	2
Drive Test Tool	7
Simulation Instrument	7
Network Tester	7

Source: GTI

TD-LTE test instruments can be roughly divided into two major categories: terminal test instruments and network test instruments. According to the usage, terminal test instruments can be classified into several categories: terminal tester (Radio Communication Tester), RF Conformance Test (RCT) system, Radio Resource Management (RRM) conformance test system, Protocol Conformance Test (PCT) system.

Terminal Radio Communication Testers

Major international test instrument manufacturers have launched commercial products, fully support 3GPP TS 36.521-1 TD-LTE terminal transmitters, receivers and RF performance measurement items.

RF Conformance Test (RCT) System

Major international test instrument manufacturers have launched commercial TD-LTE/LTE FDD RCT system, with comprehensive TD-LTE RF test capability.

Radio Resource Management (RRM) conformance test system

Major international test instrument manufacturers have launched mature RRM products supporting TD-LTE and multi-mode interoperability with TD-SCDMA/GSM systems. RRM products are stable with more and more test modes being supported.

Protocol Conformance Test (PCT) System

PCT system is necessary for terminal chipset R&D and terminal network access test. There are more than four manufacturers launching mature TD-LTE and LTE

FDD protocol test products. The next step will be to support the interoperability of TD-LTE and LTE FDD/WCDMA.

Network test instruments include network planning and optimization test instrument and R&D test instrument.

Network Planning and Optimization Instruments

12 major international test instrument manufacturers have already launched mature network planning and optimization test instrument products, many of which have been supplied to Softbank and other international operators.

R&D Test Instruments

Factors restricting development no longer exist, and the internationally renowned manufacturers have launched commercial products to support TD-LTE R&D.

2. TD-LTE Market Development

TD-LTE and LTE FDD have jointly become the world's most mainstream of the next-generation mobile broadband technology, and have been already deployed globally. On one hand, TDD operators, with technologies such as WiMAX and PHS, have an evolution path to TD-LTE. On the other hand, LTE TDD/FDD converged networking has become one of the important directions of the network deployment of LTE operators in markets with both FDD and TDD spectrum allocations.

In September 2011, Saudi operator Mobily took the lead in the global commercial TD-LTE, which officially started TD-LTE global commercial process. By the end of Jan 2013, a total of 13 operators have launched 14 commercial TD-LTE networks, including Japan Softbank, Saudi Mobily and STC, India Bharti, Brazil SKY TV, Nordic Hi3G (Hi3G launched two commercial TD-LTE networks in Sweden/Denmark), United Kingdom UK Broadband, Australia NBN, Poland Aero2, Oman Omantel, Russia MTS, China Mobile (Hong Kong) and Sri Lanka Dialog Axiata, of which UK Broadband deployed the world's first 3.5GHz TD-LTE network.

The detailed frequency bands used by each commercial network are shown in the table below.

Table 7 TD-LTE Frequency Distribution of the Global Commercial Network

No.	Operator	Band	Frequency Band
1	Japan Softbank	2.5G	2545-2575
2	India Bharti Airtel	2.3G	2300-2325 2320-2340; 2325-2345 2327.5-2347.5
3	Saudi Mobily	2.6G	2582-2602 2614-2624
4	Saudi STC	2.3G	2306-2318 2340-2380
5	Australia NBN	2.3G	2302-2400
6	Sweden Hi3G	2.6G	2570-2620
7	Denmark Hi3G	2.6G	2570-2595
8	Poland Aero2	2.6G	2570-2620
9	United Kingdom UKB	3.5G	3480-3500 3580-3600 3605-3689

No.	Operator	Band	Frequency Band
10	Brazil SKY TV	2.6G	2570-2620
11	Oman Omantel	2.3G	2370-2400
12	Russia MTS	2.6G	2595-2620
13	China Mobile Hong Kong	2.3G	2330-2360
14	Sri Lanka Dialog Axiata	2.3G	2380-2390

Until now, 29 global operators have signed TD-LTE 45 commercial contracts and 21 operators have announced clear commercialization plans. For instance, India operator Tikona plans to invest 200 million USD to launch commercial TD-LTE in 2013 and the U.S. operator Clearwire has announced to launch TD-LTE commercial network in 2013 with the first batch of 2,000 base stations to be deployed. In addition, more than 64 TD-LTE trial networks have been deployed. From the frequency point of view, the bands for commercial contracts and trial networks are concentrated in the 2.3GHz and 2.6GHz, with activity at 3.5GHz beginning to increase.

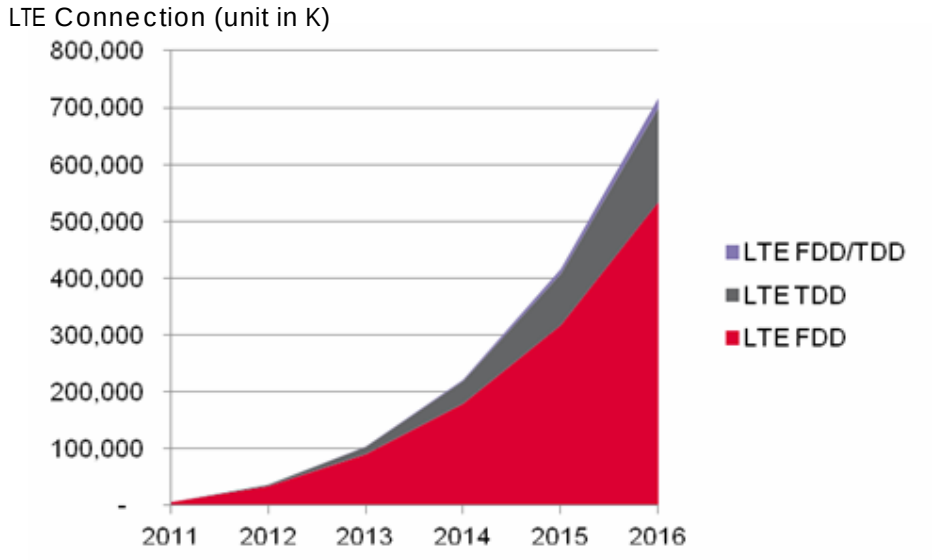
In terms of the network scale, the global number of TD-LTE base stations has exceeded 50,000 by the end of 2012. With regard to TD-LTE subscribers, it is reported that the number of global TD-LTE users has exceeded 1.3 million by the end of 2012.

As one of the largest potential markets for TD-LTE, China is actively promoting TD-LTE deployments. Pre-commercial TD-LTE network have been deployed in 15 large and medium-sized China cities with a total network scale of more than 20,000 base stations by the end of 2012. In October of 2012, Radio Regulatory Bureau of

MIIT announced the2.6GHz spectrum planning in China, allocating all the band of 2500-2690MHz (190MHz) for the development of TDD wireless broadband technology. In 2013, China Mobile will further expand the scale of the pre-commercial networks, covering more than 100 cities, with more than 200,000 base stations. It is expected that TD-LTE commercial licenses will be released around the end of 2013 in China.

The GTI Plan and Actions Declaration released by the GTI operators in February 2012 clearly stated the commercial goal 'TD-LTE base stations will reach a total of 500,000 in 2014, covering a population of 2 billion'. According to the prediction from Ovum, LTE global number of connections will be more than 700 million by 2016, of which more than 25% will be TD-LTE. It is expected that in 2013-2014, TD-LTE will have significant global market scale development.

Figure 5 Prediction of Global LTE Connections



Source: Ovum